DOCUMENT RESUME

ED 400 445 CE 072 815

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TITLE Fieldcrest Cannon, Inc. Advanced Technical Preparation. Statistical Process Control (SPC). PRE-SPC 11: SPC & Graphs. Instructor Book.
INSTITUTION Workforce Education Services, Columbus, GA.
PUB DATE 96
NOTE 49p.; For related documents, see CE 072 814-816.
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Adult Basic Education; Behavioral Objectives; *Graphs; *Industrial Training; Learning Activities; Lesson Plans; *Mathematics Skills; Pretests Posttests; *Statistical Analysis; Worksheets
IDENTIFIERS *Statistical Process Control

ABSTRACT

This instructor guide, which was developed for use in a manufacturing firm's advanced technical preparation program, contains the materials required to present a learning module that is designed to prepare trainees for the program's statistical process control module by improving their basic math skills in working with line graphs and teaching them how to plot points on a graph. The guide is divided into five sections. The first section contains the following preliminary information: individual assessment sheet, instructor notes, and primary objectives. The second section consists of lessons and worksheets on the following topics: graph-related vocabulary, types of graphs and their purposes, introduction to control charts, and plotting points. The final three sections contain answers to the worksheets, a posttest, and a posttest answer key. (MN)

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Advanced Technical Preparation
Statistical Process Control (SPC)

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PRE-SPC II
SPC & Graphs
Instructor Book

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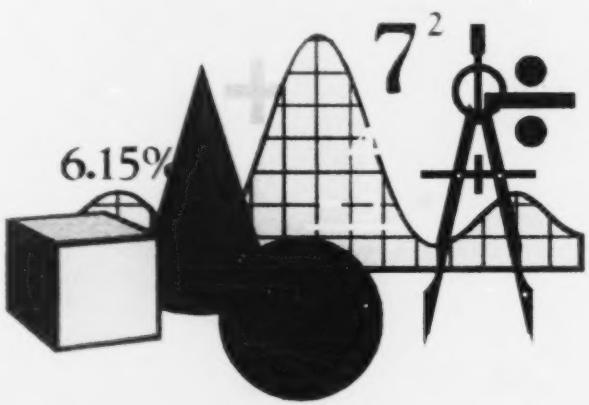

Instructor: _____

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Statistical Process Control (SPC)

PRE-SPC II
(GRAPHS)

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1996

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PRE-SPC Graphs
Section II

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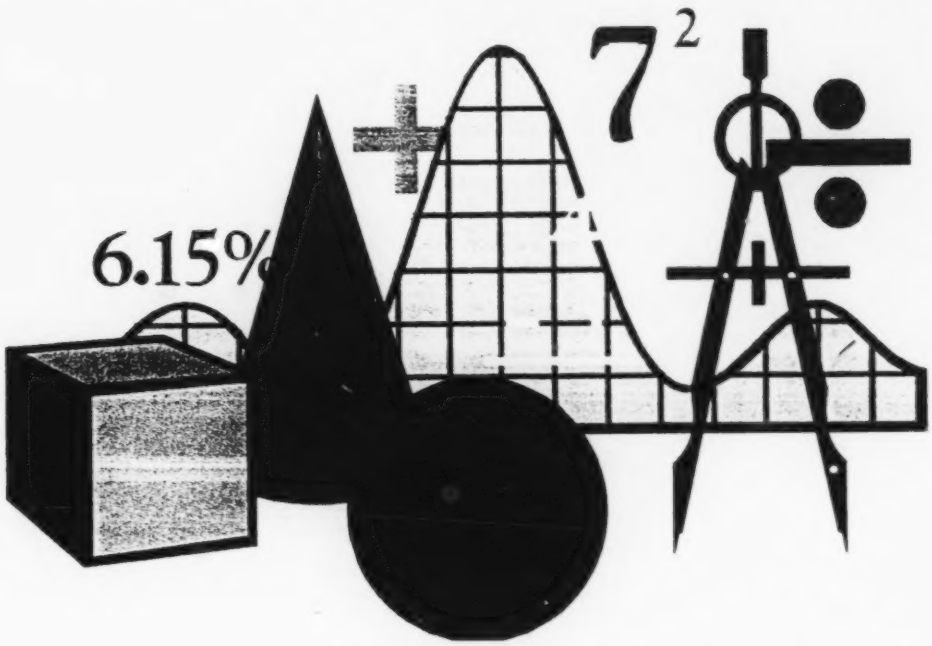
   - Plotting Points

3. Answer Key

4. Posttest

5. Posttest Answer Key



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PRE-SPC II Graphs
Individual Assessment Sheet

Associate Name _____

Social Security Number __ __ __ - __ __ - __ __ __ __

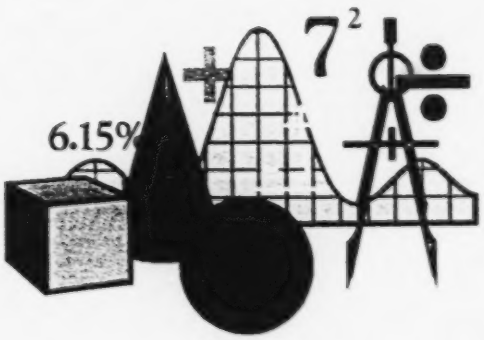
Plant _____ Location _____

Pretest *PRE-SPC II* score N/A Instructor N/A

Date of Pretest N/A Comments N/A

Posttest *PRE-SPC II* score _____ Instructor _____

Date of Posttest _____ Comments _____



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PRE-SPC II Graphs

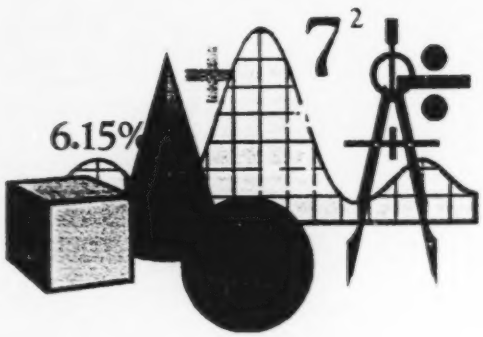
Instructor Notes

- Each associate must have access to a calculator
- Encourage associates to write words that they do not know or understand in their vocabulary notebooks (PRE-SPC II participants will need a vocabulary notebook)
- The following book is an integral part of the PRE-SPC II graph module:

  Contemporary's Real Numbers
  Developing Thinking Skills in Math
  Tables, Graphs, and Data Interpretation
  Author: Allan D. Suter

- PRE-SPC II Graph mastery level 90% (number correct /total)
- Administer a PRE-SPC II Graph posttest

  Forward all graded posttests to: Workforce Education Services
  4501 Sears Road
  Columbus, Georgia 31907-1762



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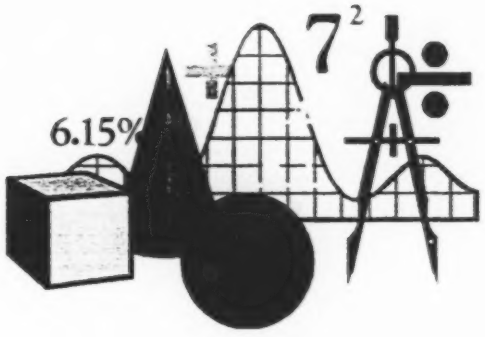
PRE-SPC II Graphs
Primary Objectives

Primary Objectives for PRE-SPC II

- Improve associates' basic math skills in working with line graphs
- Instruct associates on how to plot points on a graph
- Assist associates in preparing for participation in SPC Training (Control Charts)



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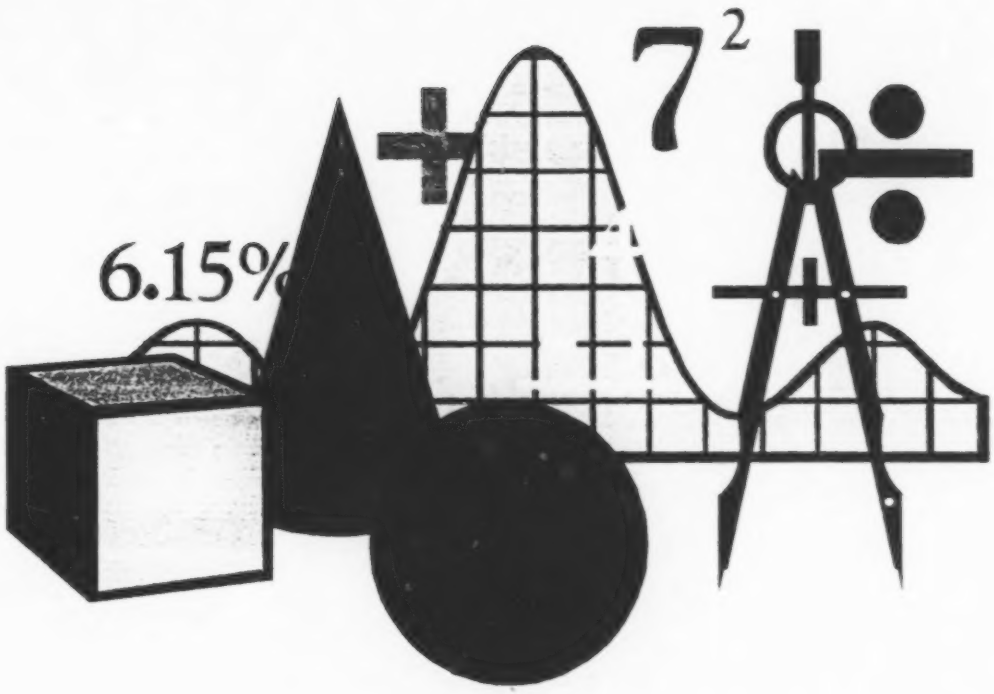
PRE-SPC Graphs
Vocabulary Quick Reference
Section 1



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Directions

- Read the following text (pp. 1&2)
- Circle words that you do not know
- Ask your instructor to pronounce the words aloud
- Write the words and their definitions in your vocabulary notebook

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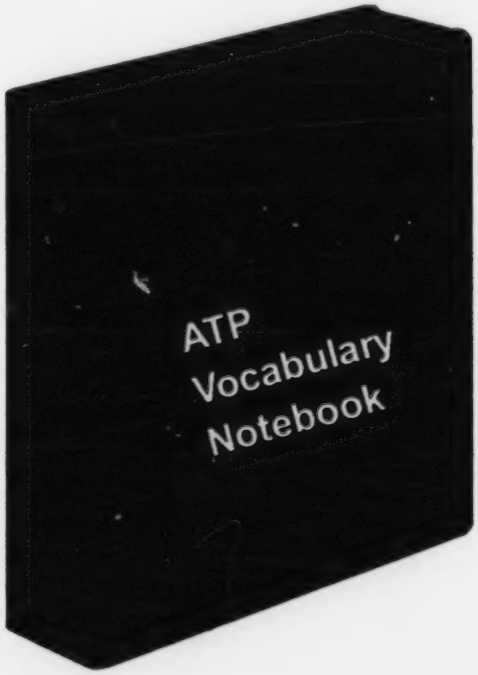
SPC Vocabulary -- Quick Reference

1.	$\overline{X}$	*Pronounced X Bar / another way to say average* Average is the result of adding a column of numbers and then dividing the total by the total number of numbers added.
2.	R	*R = range* The word range has several meanings, but only one applies to SPC. The range is the number found by subtracting the smallest measurement number from the largest measurement number.
3.	$\overline{R}$	*Pronounced R Bar* The arithmetic average of the ranges for all groups on a control chart.
4.	UCL LCL	Upper Control Limit Lower Control Limit The control limits are like boundaries. If the measurements fall outside the boundaries, the process may be "out of control." Each time part of a job is checked, the process is compared against the UCL and LCL. If the process goes out of bounds, the associate is alerted to watch the graph for a continued trend.
5.	data	Facts, measurements, or information collected for charting
6.	frequency	Rate of repetition
7.	limit	The final or furthest boundary
8.	mean	Another word for average
9.	plot	A line drawn on a chart to connect dots -- the dots represent different values
10.	process	People, materials, equipment, and environment that produce a product or service

11.	SPC	Statistical Process Control - a method of monitoring a process and its output by using statistical techniques such as charts
12.	sample	The word sample refers to a part or parts of a larger group to be selected for measurement. The sampling times and measurement numbers will be written in the correct spaces on the chart.
13.	specification	A production requirement that pertains to the acceptability of materials, measurements, or any part of a process.
14.	trend	Continuous movement up or down; a long series of points without a change in direction
15.	variables	Things or qualities that can be measured to show differences



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Directions

- Read the following text
- Circle the best answer

1. Another word for average is:

    a. mean

    b. median

    c. mode

    d. frequency

2. A continuous movement up or down; a long series of points without a change in direction is called a:

    a. chart

    b. control

    c. trend

    d. upper control limit (UCL)

3. A method of monitoring a process and its output by using statistical techniques such as charts:

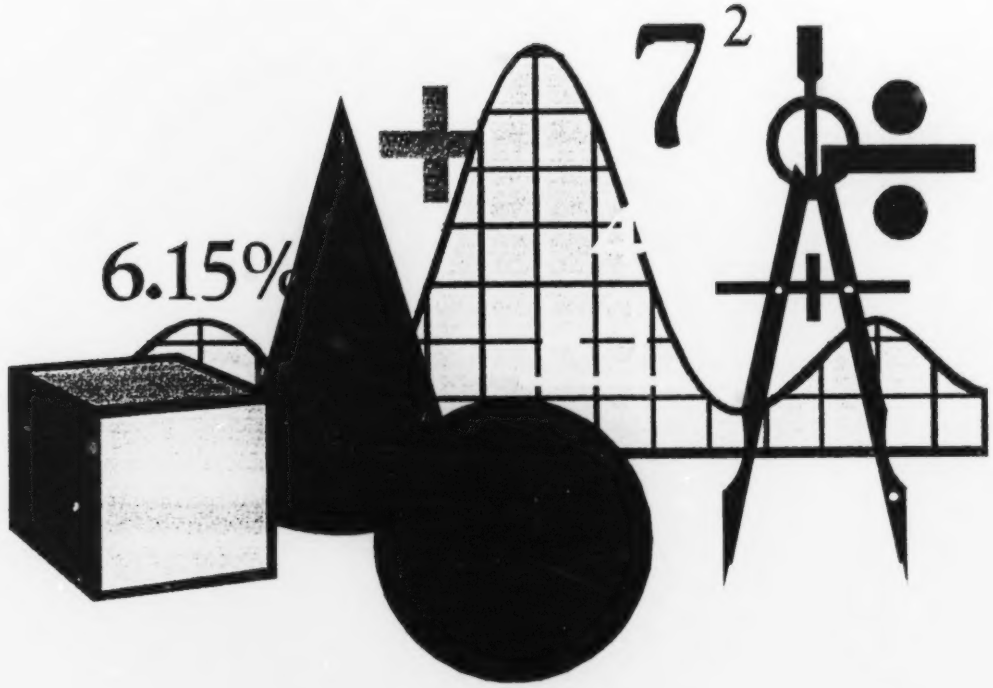
    a. statistical process control

    b. UCL

    c. SPC

    d. both a and c

PRE-SPC Graphs
What Are Graphs?
Section II



PRE-SPC GRAPHS

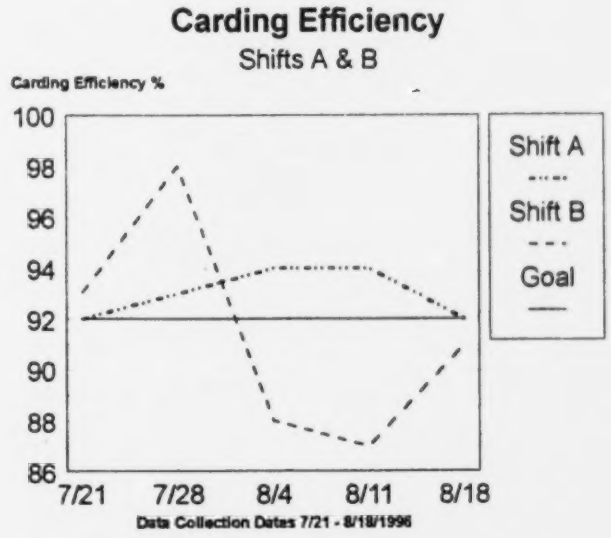
What are graphs?

A graph is a visual display of information. Since it is drawn, rather than written, a graph makes it possible for Fieldcrest Cannon associates to get a quick look at a lot of information. A graph also allows associates to make comparisons and draw conclusions.

Although there are various types of graphs, this module will focus on line graphs. A line graph is drawn with one or more thin lines that extend across the graph. This type of graph is most useful in showing trends and developments.

Directions

- Study the following graph
- Answer the questions on the next page



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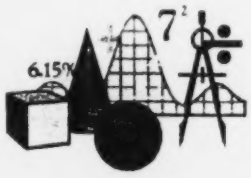


Math Tip

Use the corner of a piece of paper to help determine where points on the line are to be read on each shift.

Directions

- Answer the following questions
- Refer to the graph on page 4

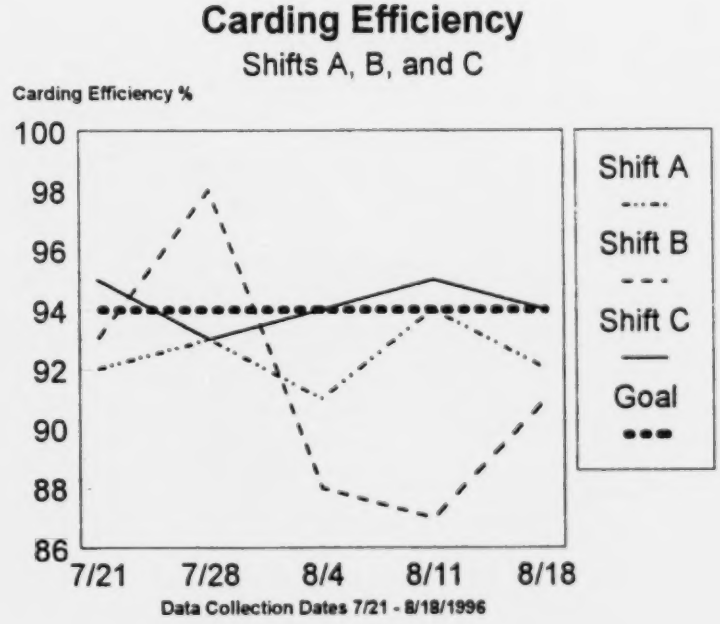
1. What is the title of the graph? _____
2. Data from which shifts are included? _____
3. What do the numbers on the bottom of the graph mean? _____
4. What is the efficiency goal for both shifts? _____
5. What is the efficiency rating for Shift A on 8/4? _____
6. What is the efficiency rating for Shift B on 7/28? _____
7. Which shift has the lowest rating on 8/11? _____

PRE-SPC GRAPHS

Fieldcrest Cannon associates use line graphs in working with statistical process control (SPC) charts. A line graph gets its name from the thin line that it uses to show data. It allows associates to:

- Establish a quick idea about the data being shown
- Compare data points
- Recognize whether the process is going to produce defects or errors
- Correct problem areas

Since every point on the line has a value, a line graph can be used to show continuous changes in data.



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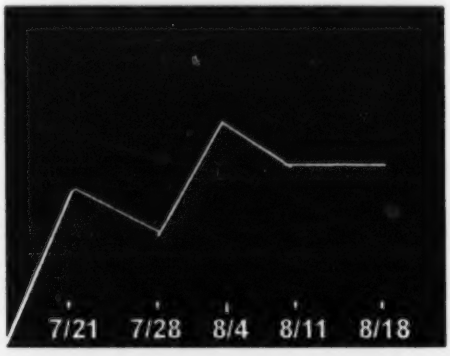


Graph Tip

The bottom row of numbers *(Horizontal or X Axis)* on the graph indicates the week of data collection.

Directions

- Refer to the graph on page 6
- Answer the following questions
- Write your answers in the blocks

1. Which shift experienced the lowest efficiency percentage ? Identify the week.

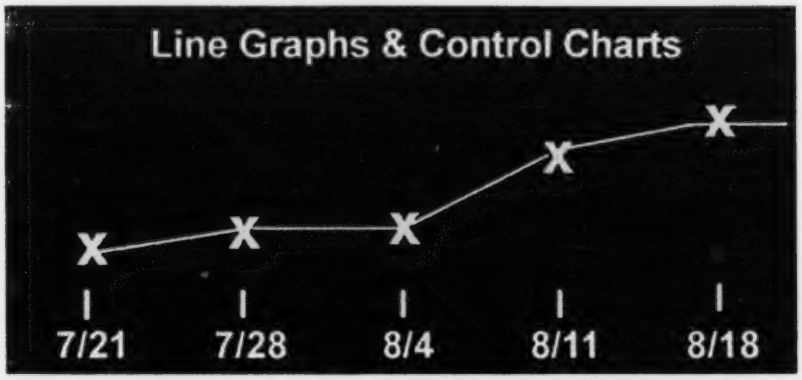
Shift ➲ _____

Week ➲ _____

2. Which shift experienced the highest efficiency percentage? Identify the week.

Shift ➲ _____

Week ➲ _____



A line graph shows changing information in visual form. The graph may represent the following changes in data:

- A line going up shows an increase
- A line going down shows a decrease
- If a line rises steadily over several points, it shows an upward trend
- If a line falls steadily over several points, it shows a downward trend

- **LOOK AT THE GRAPH.**
- **WHAT IS THE OVERALL TREND?**
- **EXPLAIN YOUR ANSWER.**

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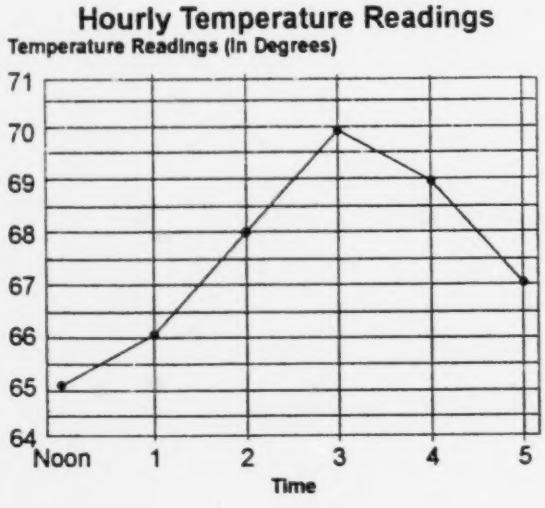
PRE-SPC GRAPH REVIEW

Graphs are pictures of numerical data. A line graph shows changing information in visual form. A line going up shows an increase. A line going down shows a decrease. If a line rises steadily over several points, it shows an upward trend. One that falls steadily over several points shows a downward trend.

Every line graph should have a title and two scales. The title tells what is being measured. The scales tell how the information is being measured. A horizontal scale goes across the graph. A vertical scale goes up and down the side of the graph.

Directions

- Study the following graph
- Fill in the blanks on page 10



Word Box

weekly	**hourly**	**daily**	**temperature**	**horizontal**
readings	**miles**	**degrees**	**right**	**bottom**

Directions

- Refer to page 9
- Select words from the word box above to complete the following sentences
- Write the words on the lines provided

The title on the previous page tells us that the graph shows _____ _____ _____. The vertical scale shows temperature readings in _____. Each dot shows the temperature reading at a certain time. The temperature is read from the left and the time is read from the _____ of the graph.

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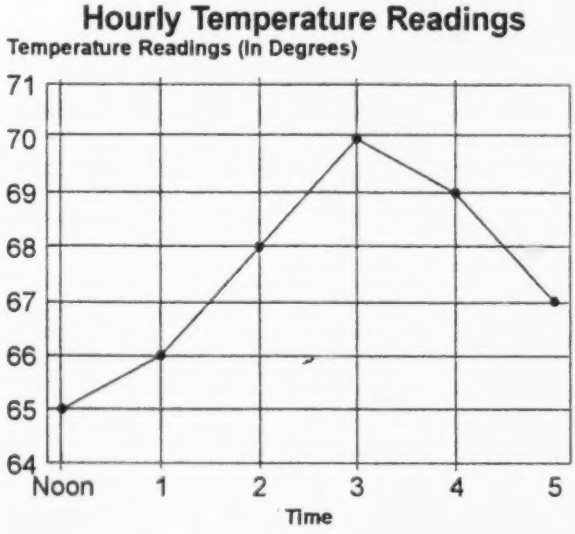

Directions

- Answer the following questions
- Write your answers on the lines provided

1. What is the highest temperature reading?

   Time _____ Temperature Reading _____

2. What was the lowest temperature reading on the graph?

   Time _____ Temperature Reading _____

3. When was there an upward trend?

   There was an upward trend from _____ *until* _____ *o'clock.*

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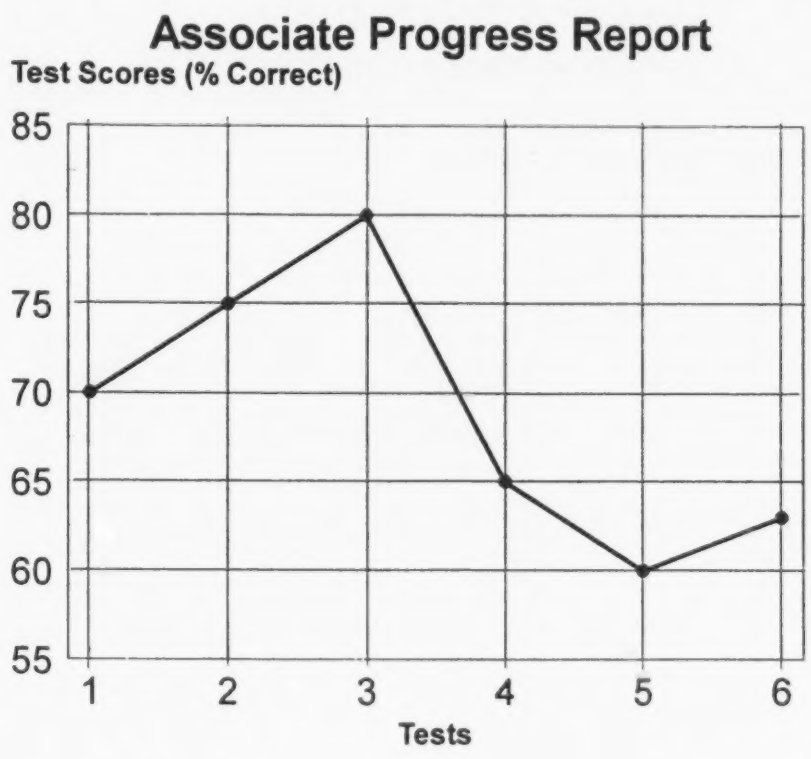
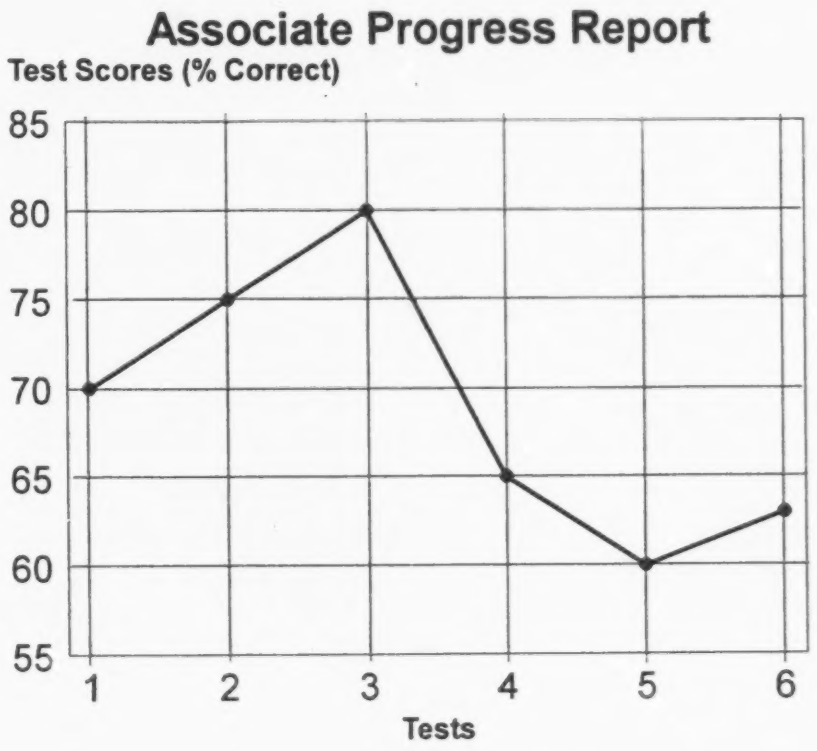


Directions

- Study the graph
- Answer the following questions

1. Overall, have the associate's test scores improved? _____

2. If 70% is the lowest passing score, how many tests did the associate pass? _____



Directions

- Study the graph
- Answer the following questions

➲ Sometimes a dot falls between two lines on a graph.
➲ The associate must estimate the answer when the dot does not fall exactly on a line.

1. Which test score does not fall on a line? _____

2. Refer to question 1. What is the estimated test score? _____

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PRE-SPC Graphs
Supplemental Material

Ask your instructor for the following book:

Contemporary's Real Numbers
Developing Thinking Skills in Math
Tables, Graphs, and Data Interpretation

Allan D. Suter (Pages 35-36)

Note: Associate may choose to complete the entire workbook.

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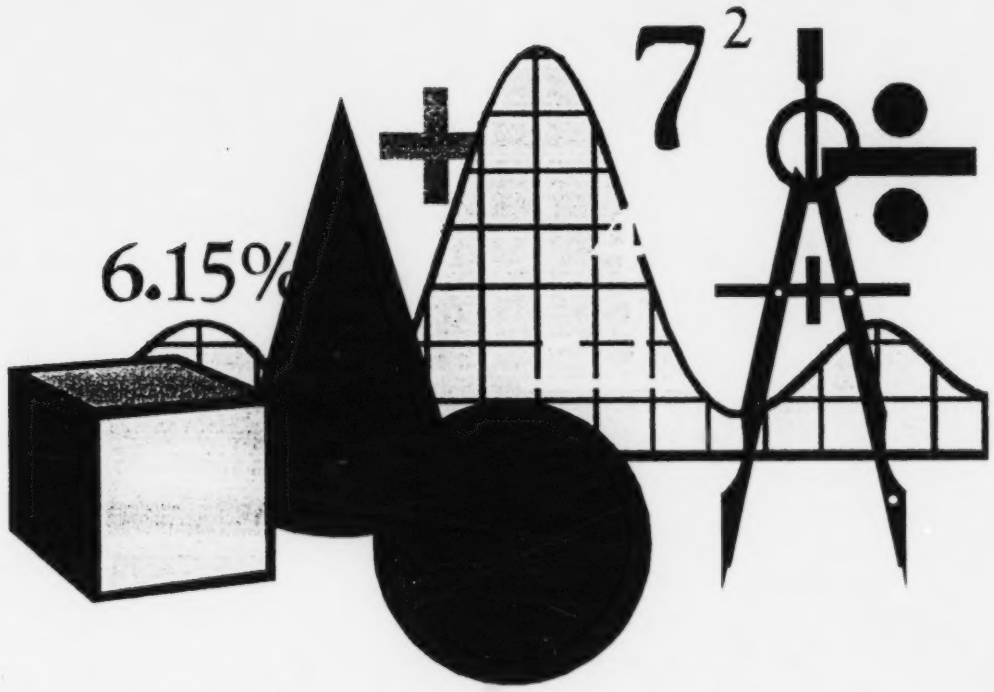
PRE-SPC Graphs
Control Chart Introduction
Section III



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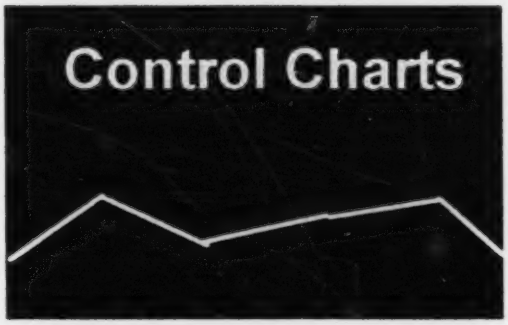

Introduction

A control chart is a special graph that shows the results of periodic small inspections over time. It is like a moving picture of a manufacturing process. The control charts will show associates when to correct a process and when to leave it alone.

Understanding key words and knowing where to locate them on the control chart are skills that will help associates. Although there are many types of control charts, a sample is shown on the next page. Some of the key words are circled. These words are defined on pages 1 and 2.

Directions
- Answer the following questions
- Write your answers in complete sentences

1. What is a control chart? _____

_____

2. What information can associates get from the charts? _____

_____

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Quality Training for Quality Improvement

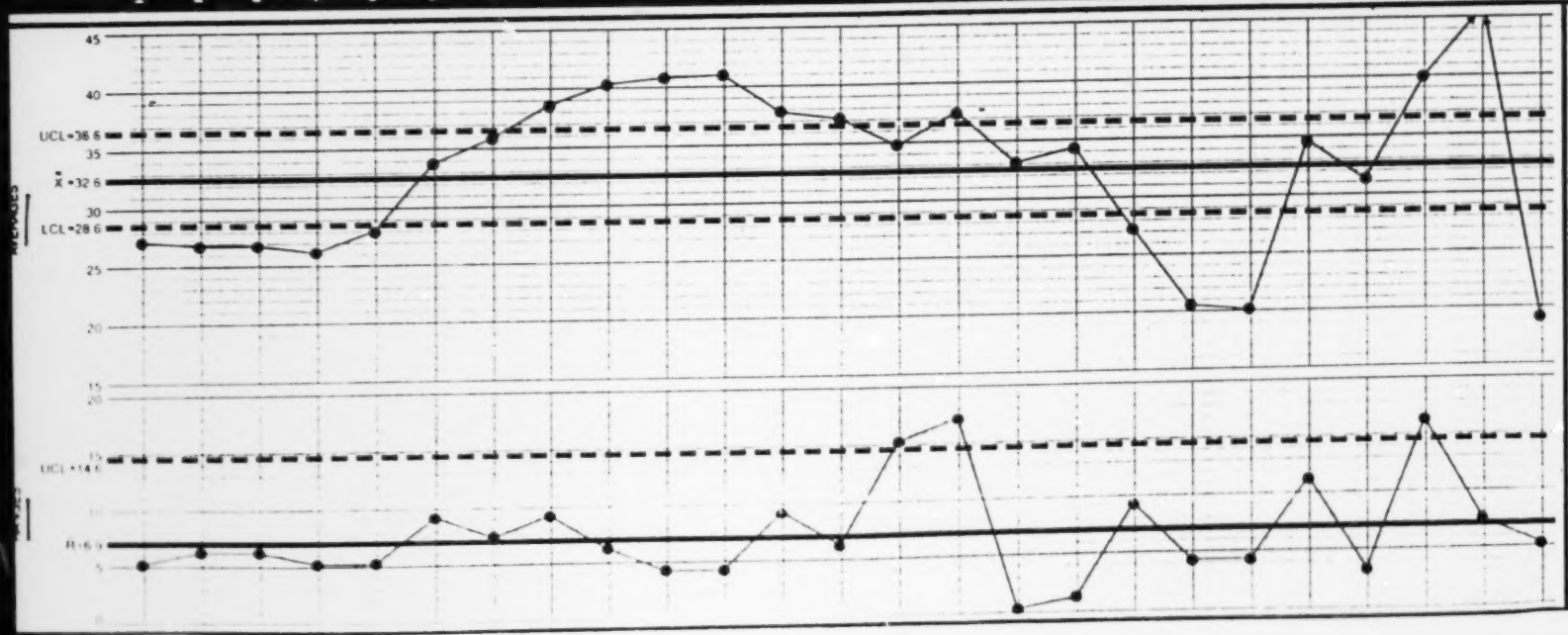
Variables Control Chart

PART NAME/NUMBER	MACHINE NAME/NUMBER	CHART TYPE ■ X̄-R ☐ MEDIAN ☐ INDIVIDUALS ☐ OTHER	CHART NUMBER 1
CHARACTERISTIC	GAUGE NAME/NUMBER	AVERAGES CHART X̿ 32.6 UCL 36.6 LCL 28.6	SAMPLE SIZE / FREQUENCY
OPERATION/DEPARTMENT	UNIT OF MEASURE ZERO	RANGES CHART R̄ 6.9 UCL 14.6 LCL 0	SPECIFICATION LIMITS UPPER LOWER

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
DATE																										
TIME																										
EMPLOYEE																										
SAMPLE MEASUREMENTS	1	28	28	28	27	26	31	36	39	44	43	43	39	39	30	34	33	34	29	20	20	36	32	39	45	21
	2	27	26	26	25	27	31	32	44	39	41	41	37	37	44	39	33	34	28	21	21	40	31	34	44	20
	3	25	25	25	25	27	30	33	35	38	39	42	43	40	40	49	33	35	30	22	22	38	33	33	44	20
	4	25	24	24	24	28	39	39	35	40	40	39	35	35	29	33	33	34	21	18	18	29	30	49	51	16
	5	30	30	30	29	31	37	39	39	40	40	39	34	34	30	32	33	34	28	21	19	30	30	44	49	18
TOTAL		135	133	133	130	139	168	179	192	201	203	204	188	185	173	187	165	171	136	102	100	173	156	199	233	95
AVERAGE (X̄)		27	26.6	26.6	26	27.8	33.6	35.8	38.4	40.2	40.6	40.8	37.6	37	34.6	37.4	33	34.2	27.2	20.4	20	34.6	31.2	39.8	46.6	19
RANGE (R)		5	8	6	5	5	9	7	9	6	4	4	9	6	15	17	0	1	9	4	4	11	3	16	7	5

INTERPRETATION GUIDELINES

- Any point outside the control limits
- A trend of 7 points, all rising or falling
- A run of 7 points, all above or below the centerline
- Any other obvious non-random pattern



DOCUMENTATION

For every change in the process, write the sample number and answer the following questions:

- What happened?
- How did it happen?
- Why did it happen?
- How was it corrected?
- Who corrected it?

Use the back if necessary

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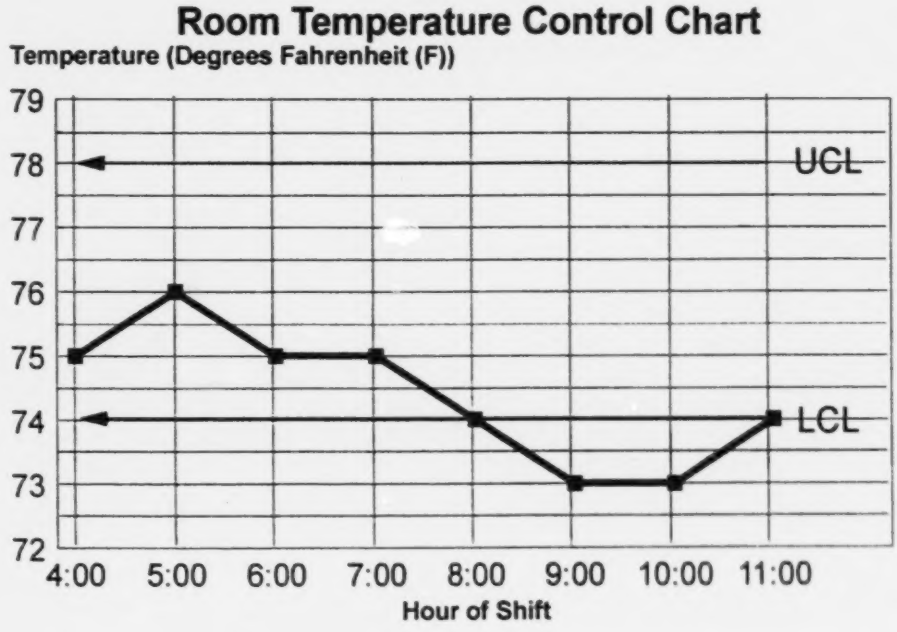
Control charts are often used to display a series of measurements. An *upper control limit (UCL)* and a *lower control limit (LCL)* are shown on the chart. The plotting of points on a control chart will show when readings or measurements are out of limits; thus, requiring corrective action. In addition, the charts will show which direction the readings or measurements are trending.



Directions

- Study the graph
- Answer the following questions

1. What temperature represents the upper control limit (UCL)? _____

2. What temperature represents the lower control limit (LCL)? _____

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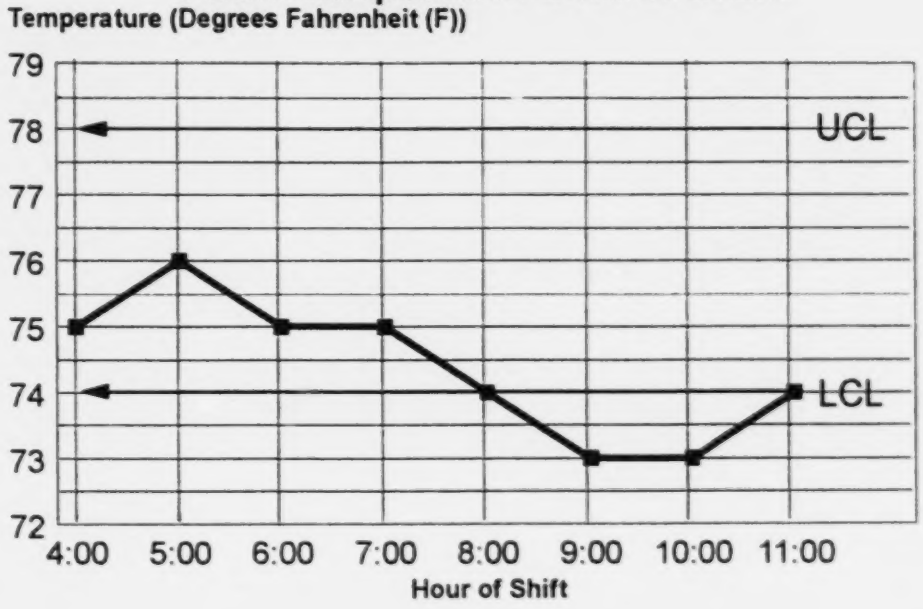
Room Temperature Control Chart



- The room temperature must be kept between 76 ± 2° F
- ± means plus or minus 2 degrees Fahrenheit, or between 74° and 78°

Directions

- Study the graph
- Answer the following questions

1. What readings are out of limits?

   Time _____ Temperature Reading _____

   Time _____ Temperature Reading _____

2. Which way did the temperature *trend* during the shift? _____

3. At what points should the associate be alerted that an adjustment in temperature may have to be made? _____

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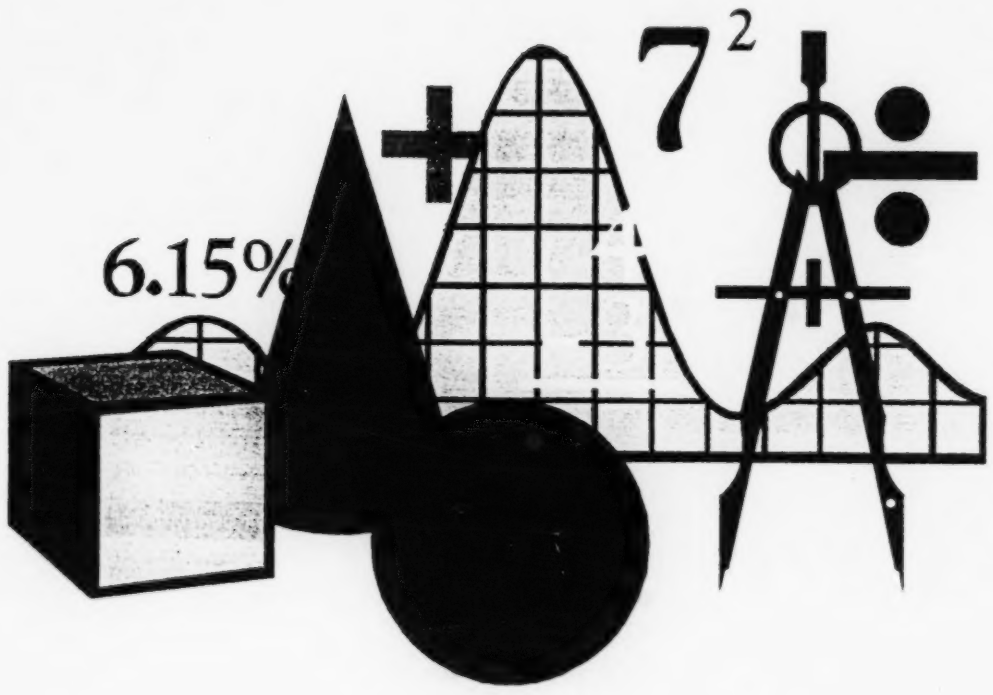
PRE-SPC Graphs
Control Chart -- Plotting Points
Section IV



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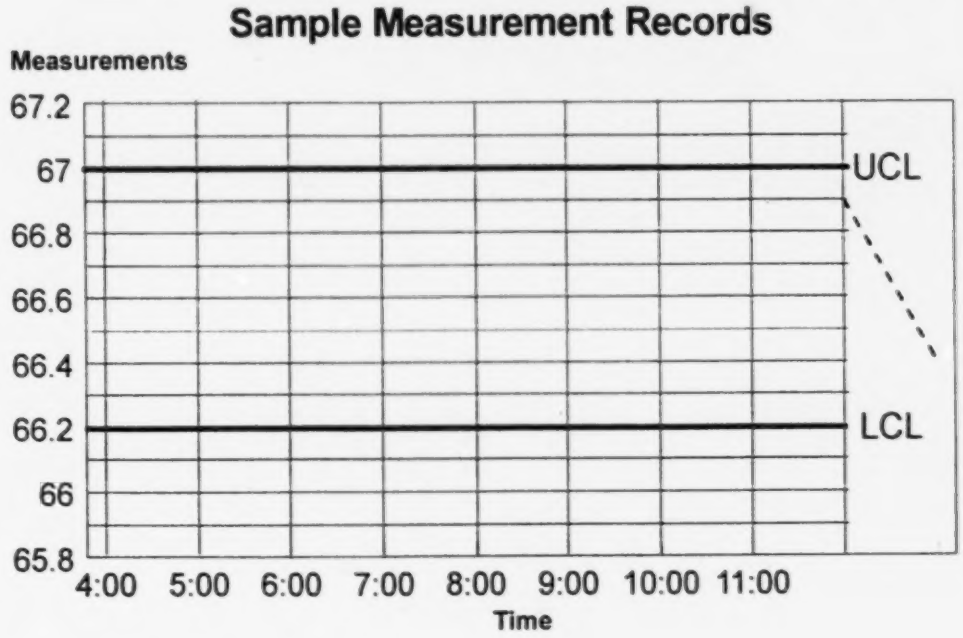
The following sample measurements were taken every hour:

Time	Measurement
4:00	66.9
5:00	67.0
6:00	66.8
7:00	66.6
8:00	67.1
9:00	66.2
10:00	66.0
11:00	66.6

Direction
Plot the measurements on the graph



☞Refer to the preceding page. The graph is similar to an SPC control chart. The plotted points within the control limits (between the UCL and LCL lines) indicate that the process is *in statistical control*. When the points are outside the control limits, the process may be *out of statistical control* -- the associate is alerted to watch the graph for a continued trend. Corrective action may need to be taken.

Directions
- Answer the following question
- Write your answers on the lines provided
- Refer to page 17

When could the process be out of statistical control?

1. Time _____ Measurement _____

2. Time _____ Measurement _____

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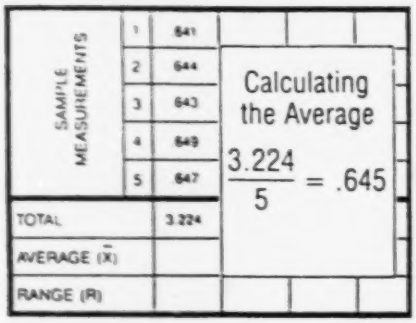
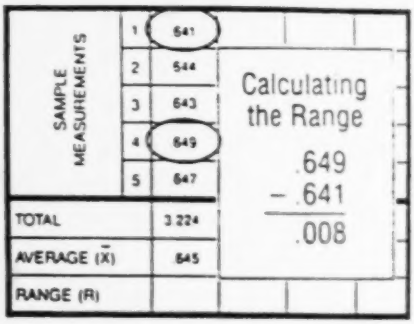
SPC TEAM INSTRUCTIONS

1. Record sample measurements -- readings are listed below
2. Calculate the average and range for each sample
3. Use a calculator

SPC Team Readings

Sample	1	2	3	4	5
Measurements	28	28	28	27	26
	27	26	30	25	27
	25	25	25	25	27
	25	24	24	24	25
	30	30	26	29	28
Totals					
Averages					
Ranges					

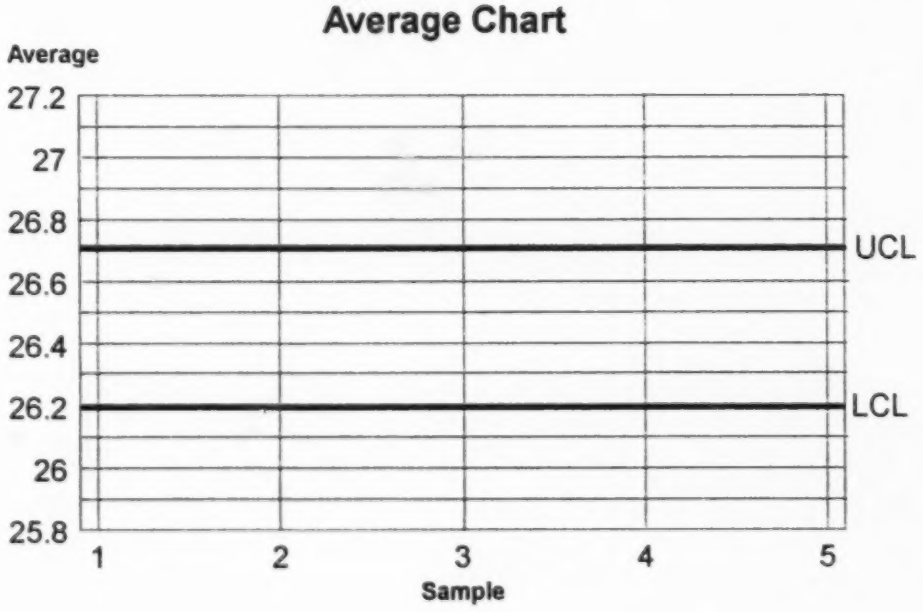




Note: Work teams are recommended.

SPC TEAM INSTRUCTIONS CONTINUED

1. Refer to page 19
2. Plot the average for each sample



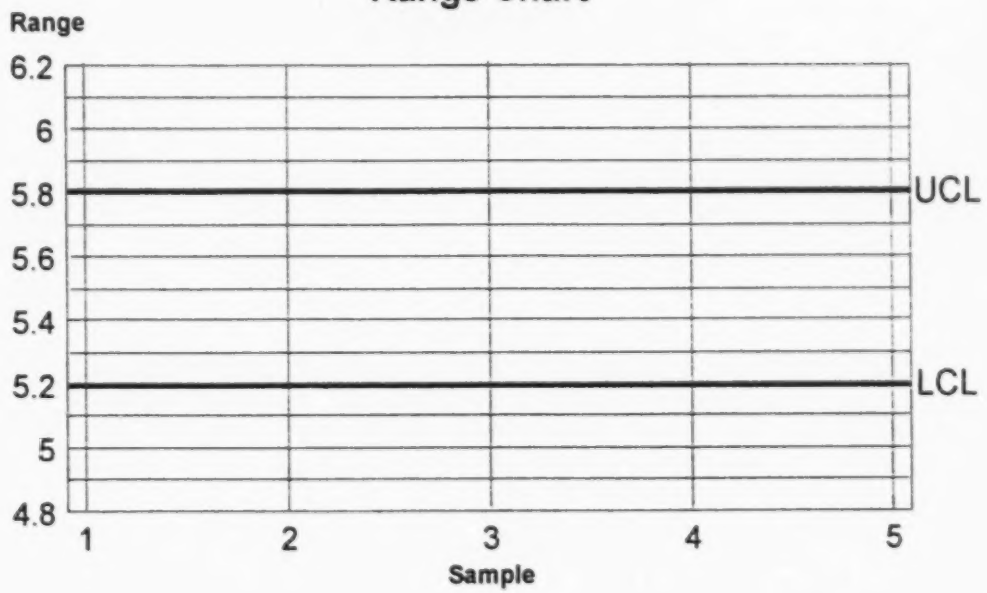
Are any of the averages out of the control limits? _____
Identify the averages outside the control limits. _____

Note: Work teams are recommended.

SPC TEAM INSTRUCTIONS *CONTINUED*

1. Refer to page 19
2. Plot the range for each sample (1-5)

Range Chart



Are any of the ranges out of the control limits? _____

Identify the ranges outside the control limits. _____

Note: Work teams are recommended.

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PRE-SPC Graphs
Supplemental Material

Ask your instructor for the following book:

Contemporary's Real Numbers
Developing Thinking Skills in Math
Tables, Graphs, and Data Interpretation

Allan D. Suter (Pages 37-39)

Note: Associate may choose to complete the entire workbook.

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PRE-SPC II
SPC and Graphs

Answer Key

Page 1A (5 points)
Check vocabulary notebook *(words and definitions will vary)*

Page 1 & 2 (See Page 1A)

Page 3 (3 points)
1. a 2. c 3. d

Page 4 (0 points)

Page 5 (7 points)
1. Carding Efficiency 2. A & B 3. Dates the information was collected 4. .92 or 92%
5. 94% 6. 98% 7. Shift B

Page 6 (0 points)

Page 7 (4 points)
1. shift B week 8/11 2. shift B week 7/28

Page 8 (2 points)
Sample answer: There tends to be an upward movement -- assuming the points are within the control limits.
Use discretion when awarding points

Page 9 (0 points)

Page 10 (2 points)
Hourly Temperature Readings
degrees
bottom

Page 11 (3 points)
1. 3:00 P.M. 70° 2. Noon 65° 3. Noon 3:00 P.M.

Page 12 (2 points)
1. No 2. 3

Page 13 (2 points)
1. #6 2. Approximately 63

Page 14 (2 points)
1. A control chart is a graph showing the results of periodic small inspections. *(answers may vary)*
2. Associates can determine if a process needs to be corrected.

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PRE-SPC II
SPC and Graphs

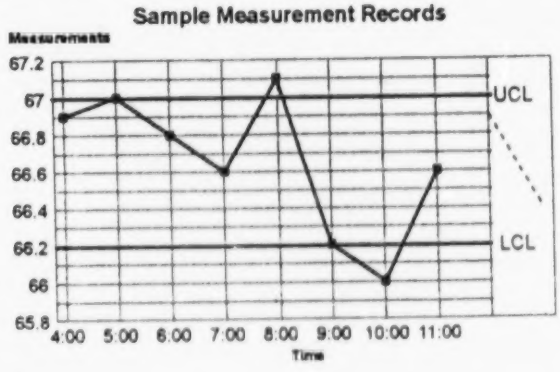
Answer Key *(Continued page 2)*

Page 15 (2 points)
1. 78° 2. 74°

Page 16 (3 points)
1. 9:00 73°
10:00 73°

2. Downward trend 3. As soon as the temperature drops below LCL -- 74° *(Between 9:00 and 10:00)*

Page 17 (9 points)



Page 18 (4 points)
1. 8:00 67.1
2. 10:00 66

Page 19 (20 points)

Sample	1	2	3	4	5
Measurements	28	28	28	27	26
	27	26	30	25	27
	25	25	25	25	27
	25	24	24	24	25
	30	30	26	29	38
Totals	135	133	133	130	133
Averages	27	26.6	26.6	26	26.6
Ranges	5	6	6	5	3

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PRE-SPC II
SPC and Graphs

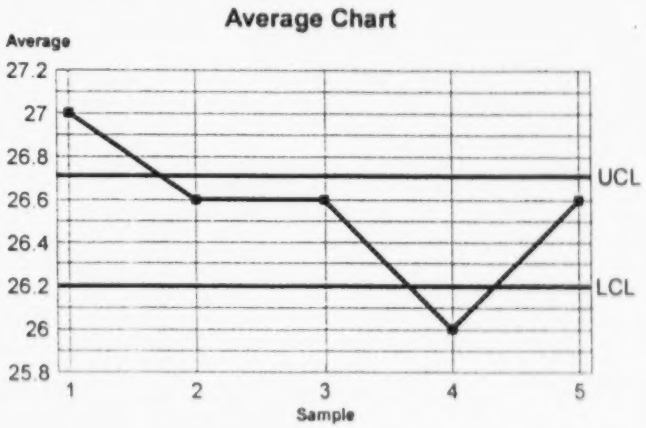
Answer Key *(Continued page 3)*

Page 20 (15 points)

⇒There are two points out of statistical control

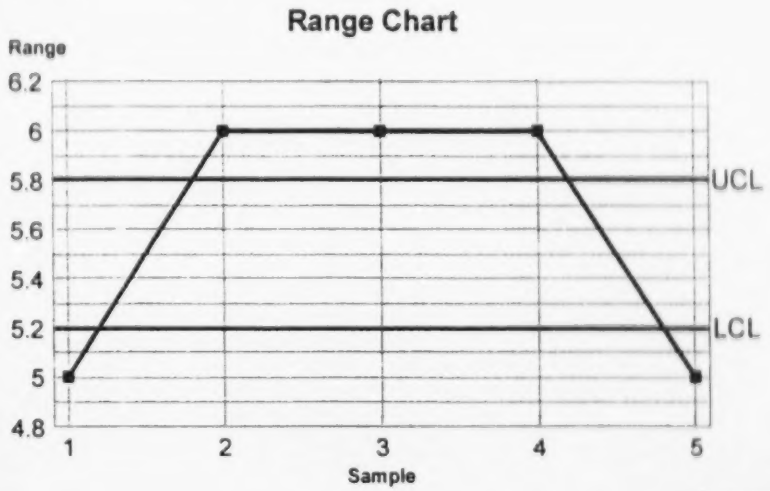
⇒Sample 1 -- average 27

⇒Sample 4 -- average 26



Page 21 (15 points)

⇒All points are out of statistical control



Maximum Points = 100

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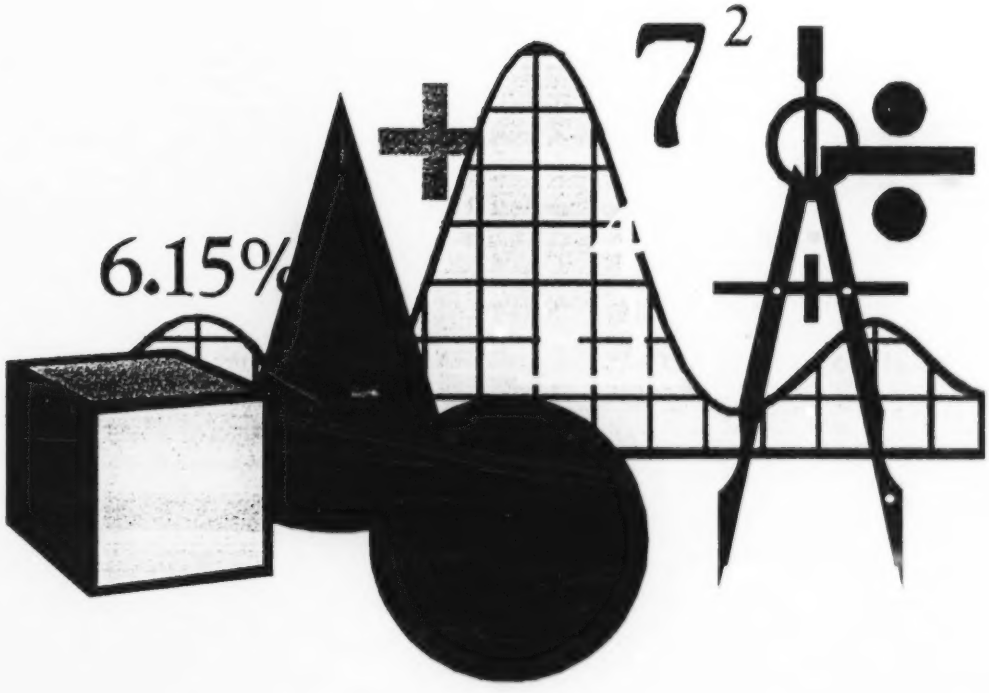
PRE-SPC Graphs
Control Chart -- Posttest
Section V



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Directions

- Add the total
- Calculate the sample average
- Calculate the range for each sample measurement
- Calculate the process average *(Need help? See page 49, PRE-SPC I)*
- Use a calculator

Total, Sample Average, Range, and Process Average

Sample Measurement	Monday Sample #1	Tuesday Sample #2	Wednesday Sample #3	Thursday Sample #4	Friday Sample #5
1	28	28	30	30	26
2	27	26	26	25	27
3	25	25	25	24	27
4	25	24	24	26	28
5	+ 30	+ 30	+ 28	+ 28	+ 31
Total					
Average					
Range					

What is the process average? $\overline{\overline{X}}$ = _____

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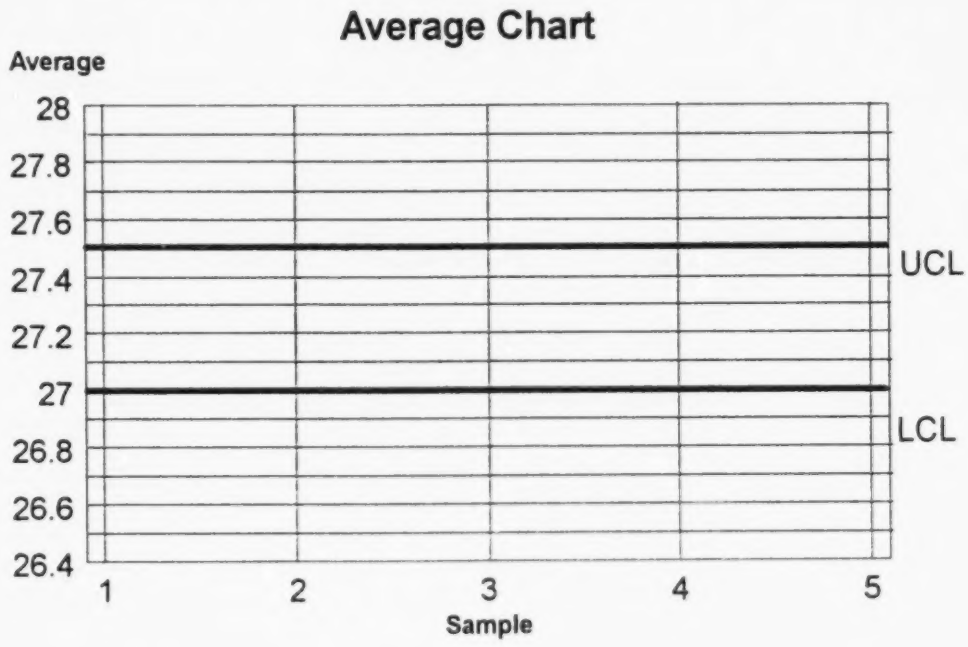
Directions
1. Refer to page 22
2. Plot the averages



1. Identify points out of the control limits.

Sample _____ Average _____

Sample _____ Average _____

Sample _____ Average _____

Sample _____ Average _____

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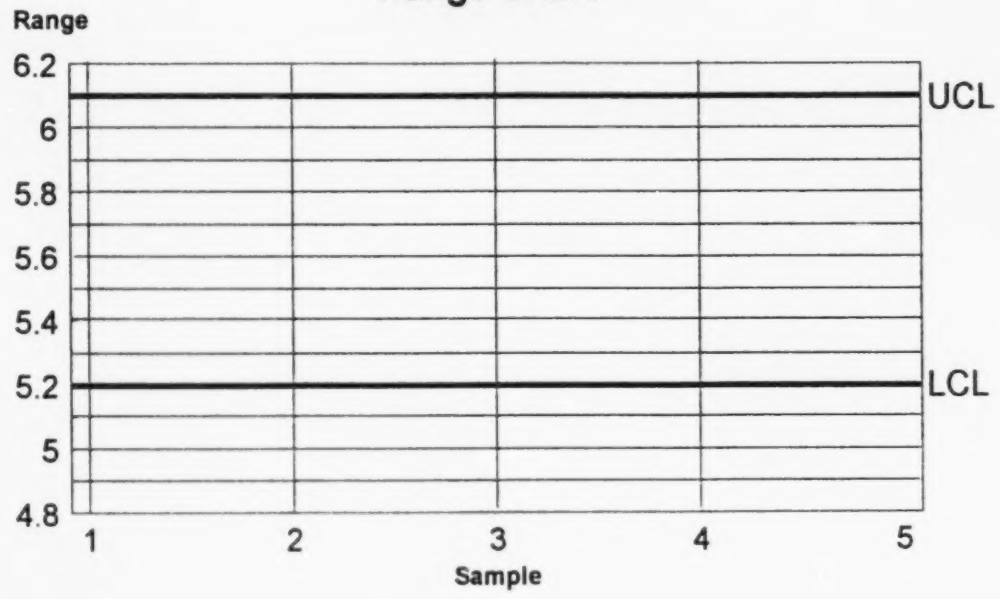
Advanced Technical Preparation (ATP)

Directions
1. Refer to page 22
2. Plot the ranges

Range Chart



1. Identify points outside the control limits.

Sample _____ Range _____

Sample _____ Range _____

Sample _____ Range _____

Sample _____ Range _____

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Advanced Technical Preparation (ATP)

PRE-SPC II
SPC and Graphs
Posttest

Answer Key

Page 22 (40 points)

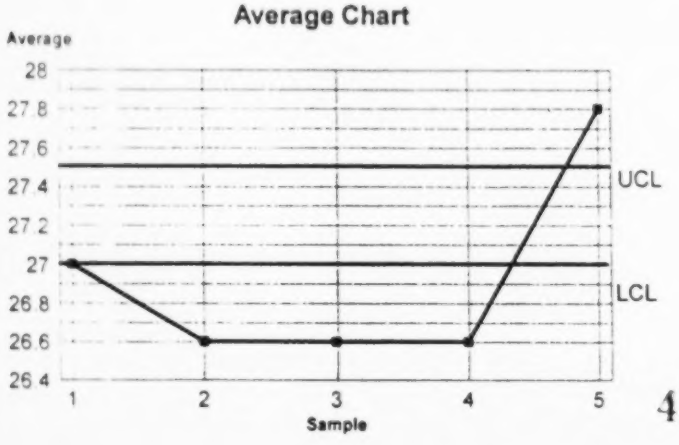
Sample Measurement	Monday Sample #1	Tuesday Sample #2	Wednesday Sample #3	Thursday Sample #4	Friday Sample #5
1	28	28	30	30	26
2	27	26	26	25	27
3	25	25	25	24	27
4	25	24	24	26	28
5	+ 30	+ 30	+ 28	+ 28	+ 31
Total	135	133	133	133	139
Average	27	26.6	26.6	26.6	27.8
Range	5	6	6	6	5

$\overline{\overline{X}}$ = 26.92

134.6/5=26.92

Page 23 (30 points)

Sample 2	26.6	Sample 3	26.6
Sample 4	26.6	Sample 5	27.8



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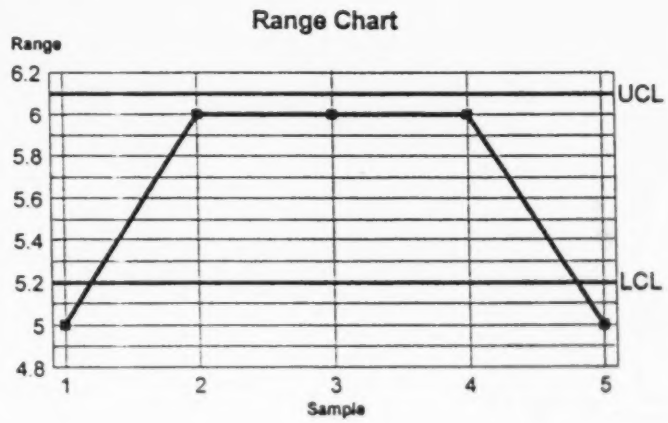
PRE-SPC II
SPC and Graphs
Posttest

Answer Key

Page 24 (30 points)
Sample 1 5
Sample 5 5



Maximum Points = 100